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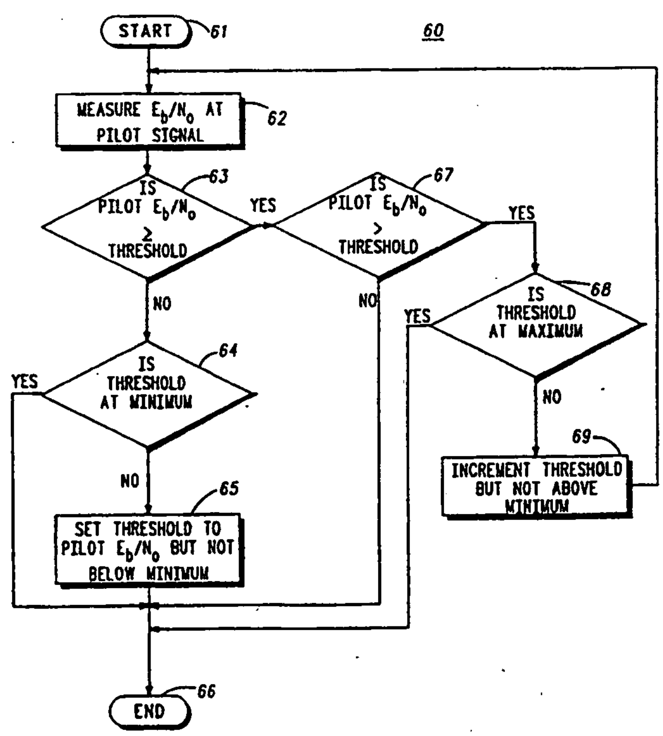
(54) Title: A METHOD FOR COMPENSATING FOR CAPACITY OVERLOAD IN A SPREAD SPECTRUM COMMUNICATION SYSTEM

(57) Abstract

A method for compensating for capacity overload in a communication system by first determining the received signal power level at a base site (62) is described. The power level is compared with a threshold power level (63). If the received power level is greater than the threshold, the signal-to-noise ratio for the system is reduced (65). With the acceptable signal-to-noise ratio reduced, the subscriber power will be reduced. The received signal power level at the base site will then return to the threshold level. Alternatively, a signal-to-noise ratio of a pilot signal can be determined (62) at the base. The signal-to-noise ratio is compared to a threshold signal-to-noise ratio (63). If the signal-to-noise ratio of the pilot is less than the threshold, the threshold level is reduced (65). With the acceptable signal-to-noise ratio reduced, the subscribers are directed to reduce their power.



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A METHOD FOR COMPENSATING FOR CAPACITY OVERLOAD IN A SPREAD SPECTRUM COMMUNICATION SYSTEM

Field of the Invention

The present invention relates, in general, to communication systems and, more particularly, to spread spectrum communication systems.

Background of the Invention

In a cellular communication system using spread spectrum technology, such as Code Division Multiple Access (CDMA), the spectrum is divided into 40 frequency bands. The 40 bands are divided between wireline and non-wireline applications, generally assigning 20 bands to each. The 20 bands are equally divided with 10 bands used for forward communication with the base station as the transmitter and 10 bands used for reverse communication with the mobile as the transmitter. Each band is typically 1.2288 MHz wide and will handle multiple users simultaneously.

In this description, calls and users are used interchangeably. A band that supports X users supports X calls. The capacity of a band in number of users always refers to full rate (9600 baud) users unless otherwise stated. A band that supports X full rate (9600 baud) users, will support 2X half rate (4800 baud) users, or 4X quarter rate (2400 baud) users. The band

will also support a certain number of variable rate users (9600, 4800, 2400, or 1200) with the exact number of users dependent on the amount of time spent at each baud rate.

In operating at system capacity, accurate mobile transmit power control is very important. Mobile power is controlled from the base station by transmitting power control data to every transmitting mobile. The base station can direct each mobile to increase or decrease its transmitting power, typically in preset increments (e.g. 0.5 dB).

Channel interference is an on going problem in any communication system. The interference is generally caused by a combination of thermal noise (KTB), man made noise, and co-channel noise. Co-channel noise results from other calls on the same channel, either within the same cell or from another cell. As the interference within a cell increases, the base site will direct the subscriber units to increase power. This increased power will cause interference in other cell sites which will then raise their power to compensate. This will escalate until the maximum power output of one or more subscribers is reached. At this point, the signal-to-noise ratio will drop below a preselected minimum level and one or more calls will be dropped.

Therefore, it is an on-going effort for cellular designers in a CDMA system to maximize the number of users on a system while at the same time avoiding the noise problems caused by those users.

Summary of the Invention

The present invention provides a method for compensating for capacity overload in a spread spectrum

communication system by first determining the received signal power level at a base site. This power level is compared with a threshold power level. If the received power level is greater than the threshold level, the reverse (subscriber to base) signal-to-noise ratio for the system is adjusted (reduced). With the acceptable signal-to-noise ratio reduced, the subscribers are directed, through a power control signal from the base site, to reduce their transmitted power. The subscribers then adjust (reduce) their transmitted power bringing the received signal power level at the base site back to the threshold level.

Alternatively, a signal-to-noise ratio of a reverse pilot signal can be determined at the base site. The signal-to-noise ratio is then compared to a threshold signal-to-noise ratio. If the signal-to-noise ratio of the pilot is less than the threshold, then the threshold level is adjusted (reduced). With the acceptable signal-to-noise ratio reduced, the subscribers are directed, through a power control signal from the base site, to reduce their power. The subscribers then adjust (reduce) their power bringing the received signal power level at the base site back to the threshold level.

These methods permit the system to accommodate more users without resulting in an escalation of the power level of the cell triggered by the additional noise generated.

Brief Description of the Drawings

FIGS. 1A-1C are abstract representations of power use by user within a communication system;

FIG. 2 is a graph illustrating the power level of the signals of FIG. 1A;

FIG. 3 is a graph illustrating the power level of the signals of FIG. 1C;

FIG. 4 is a chart of the signal-to-thermal noise ratio vs. the number of users for set signal-to-noise ratios;

FIG. 5 is a graph illustrating the power level of another communication system;

FIG. 6 is a block diagram of a process representing the present invention;

FIGS. 7A-7C are abstract representations of the power use by user of FIGS. 1A-1C, respectively, incorporating a reverse pilot signal; and

FIG. 8 is a graph illustrating the signal power level of the signals for FIG. 7A.

Detailed Description of the Drawings

Referring initially to FIGS. 1A-1C, abstract representations of power usage by user within a communication system is illustrated. Within these figures, the areas represent the power of various signals over the 1.2288 MHz bandwidth. For example, KTB is the power of the thermal noise signal where: K is Boltzmans constant; T is the temperature in degrees absolute (Kelvin); and B is the signal bandwidth in hertz (Hz). The power of the KTB signal is constant in each of FIGS. 1A-1C. For purposes of this discussion, we will use a KTB of -113 dBm.

When a single user is on the system, FIG. 1A, the power of the user's signal must be -127 dBm (14 dBm below KTB) in order to provide an Energy per bit to total Noise ratio (E_b/N_o) of 7 dB. The 7 dB number was

selected as a ratio which will provide a preferred audio signal quality. This figure will vary for each system depending upon the particular environment of the system and is used herein only for illustrative purposes.

The calculation of the -127 dBm figure for the single user signal of FIG. 1 is demonstrated with use of the graph of FIG. 2. Here, noise (N_o) for the 1.2288 MHz Bandwidth is shown as -113 dBm. When the noise signal is processed from a 1.2288 MHz bandwidth signal to a 9.6 KHz bandwidth, a 21 dB reduction is achieved as shown in equation 1.

$$10\log_{10}(9.6/1.2288) = -21 \text{ dB} \qquad (1)$$

This places the noise signal at -134 dBm at a 9.6 KHz bandwidth. Therefore, to achieve an E_b/N_o of 7 dB, a -127 dBm (-134+7) signal (E_b) must be provided at the 1.2288 MHz bandwidth. To achieve the -127 dBm after processing, a -148 dBm signal (-127-21) is needed before adding 21 dB of processing gain. This works out to the receive power of the user being 14 dB below KTB.

The purpose of the 7 dB E_b/N_o level is to provide a desired audio quality in the signal. If the E_b/N_o of a particular signal should drop below 7 dB, the cell site would look to hand-off the call. Failing a hand-off, the system may terminate the call.

In FIG. 1B, a representation of a system having an additional 19 users is illustrated. With respect to user 1, the 19 new users provide additional noise. While KTB is a smaller proportion of the circle, as compared with FIG. 1A, the overall area of KTB is the same. However, because of the added noise from the additional users, the area (power) of user 1 has increased. The dashed spiral line in FIG. 1B starts at

the user power level for a single user system and moves outward as additional users are added; until reaching the current radius of the circle with 20 users.

In FIG. 1C, the system has reached 25.5 users, the point where KTB has the same power as one user. Adding 24.5 users to KTB for an equivalence of 25.5 users; each of which are contributing noise to the call of the remaining users. Again, the area of KTB has remained the same throughout the addition of users, while the power of user 1 has increased to compensate for the additional noise.

In FIG. 3, a graph of the KTB, Noise, and User 1 power levels is shown. As illustrated, the power level of KTB has not changed. However, the total interference (N_o), including KTB, has increased from -113 dBm to -99 dBm at 1.2288 MHz. Reducing the power level by 21 dB when the interference is process to a 9.6 KHz signal (see equation (1) above), the power level is -120 dBm. To provide an E_b/N_o of 7 dB, the user signal must be -113 dBm (-120 + 7) at 1.2288 MHz. Therefore, as the number of additional users increase, the signal level of the target user must increase from a level 14 dBm below KTB, to a level equal to KTB.

In the present communication systems, the maximum number of users, here 26.5 (which would be rounded to 26 full rate users), are predetermined based upon a set E_b/N_o, here 7 dB. This means that a 27th user would be prevented from obtaining access to the system. If the 27th user was not prevented from entering the system, the power needed by each subscriber to overcome the interference would escalate to infinity. This is demonstrated in the graph of FIG. 4. In this graph, the abscissa is the number of users in the system and the ordinate is E_b/KTB. At a constant E_b/N_o of 7 dB, the

E_b/KTB increases from around 33 dB for 26 users to infinity for 27 users. As shown by the column labeled "KTB Equivalence in Number of Users", the constant KTB power is fit into the equivalent of 0.1 users at 26 users. In relation to FIGS. 2 and 3, as the number of users increases, the constant KTB is forced into narrower slices of the pie tending toward zero. This in turn, since the KTB power is constant, increases the radius of the pie toward infinity.

As the subscribers hit their maximum power levels, shown as 6.3 watts for mobiles and 300 milliwatts for portables, the effective range of the cell shrinks, tending toward zero. This results in calls being dropped until the system can again be brought under control. The system would be brought under control by dropping the calls having an E_b/N_o below 7 dB.

This problem is compounded by the fact that the internal interference of one cell is the external interference of another cell. The graph of FIG. 5, a system is shown having a primary user; 16 additional users; KTB; and 8.5 users worth of interference from outside the cell. If the interference were to increase, the power output of the 17 users would have to increase to keep the interference segment from forcing out one of the users. As the interference increases toward infinity, as in the example above, the power output by the resident users of this cell would also increase toward infinity. This demonstrates that one cell going out of control can have a ripple effect throughout the system.

In addition, FIG. 5 illustrates that having a preset maximum number users for a system does not alleviate the power control problem. In FIG. 5, while only 17 resident users are on the system, it is at

capacity because the interference occupies the additional 8.5 user slots. If an 18th user enters the system, which would be permitted since the number of resident users is not at its maximum, the power levels will escalate out of control as described above with FIG. 4. One possible solution would be to set the maximum number of users to 17, or some number less than full capacity. Since the interference will vary anywhere from 0 users to more than 8.5 users, the maximum capacity would have to be chosen based upon the worst case of interference anticipated. This would waste system capacity by restricting new users even when the interference is less than the worst case design.

A solution to this problem is to permit the E_b/N_o level to float depending upon the circumstances. Returning to FIG. 4 and the above example, the addition of the 27th user when E_b/N_o is set at 7 dB caused the power in the system to escalate out of control. In the present invention, the system is permitted to reduce the E_b/N_o level. If the E_b/N_o is reduced from 7 dB to 6 dB, the E_b/KTB value drops from infinity to around 14 dB. This will also cause all of the subscribers in the system to reduce their power to match a 6 dB E_b/N_o level. It should be noted here that the E_b/N_o reduction does not need to be a full decibel but could be a fraction of a decibel. In addition, the system need not attempt to totally compensate for the additional user all in one step. The E_b/N_o may be reduced in incremental steps until a level is reached where all of the calls may be accommodated.

A drawback to this process is that when the E_b/N_o level is reduced, the quality of all of the calls in the system is reduced slightly. In order to keep the quality of the calls from being degraded too much, a

minimum E_b/N_o threshold level is established. Once the minimum E_b/N_o is reached, subscribers that are unable to operate at that minimum level would be handed-off, if possible.

As calls are completed and the number of users begins to drop, the E_b/N_o would increase incrementally to the original threshold value.

While this method permits the addition of users, the power control problems still remain. Once the E_b/N_o hits its minimum, the next user could push the system over the edge. One solution to this problem is to preset the maximum number of users permitted on the system. However, as set forth above in the description of FIG. 5, this does not always resolve the problem. Therefore, the present invention adds a reverse pilot signal at the base station to serve as a power limit. This signal would occupy a special channel at the base station; is maintained at a constant power level; and is not controlled by the base station.

The pilot signal would be used to determine when the E_b/N_o threshold level needed adjustment. To determine when adjustment is needed, either feedback or hysteresis can be used. One particular method, generally designated 60, of implementing this invention is demonstrated in FIG. 6. This embodiment utilizes the hysteresis approach. It commences at block 61 and continues to block 62 where the E_b/N_o of the pilot is determined.

Process 60 then determines if the E_b/N_o of the pilot is greater than or equal to the threshold E_b/N_o of the system, decisions step 63. If the pilot E_b/N_o is not greater than or equal the threshold, process 60 determines if the threshold is already at system minimum, decision step 64. If the threshold is at

minimum, process 60 ends, step 66. If the threshold is not at minimum, the threshold E_b/N_o is set equal to the pilot E_b/N_o, but not below minimum threshold, step 65. Process 60 then ends, step 66.

If the pilot E_b/N_o was greater than or equal to threshold, step 63, process 60 proceeds to decision step 67 where it is determined if the pilot E_b/N_o is greater than the threshold. If the pilot E_b/N_o is not greater than the threshold (e.g. the pilot E_b/N_o is equal to the threshold), then process 60 ends, step 66.

If the pilot E_b/N_o is greater than threshold, decision step 68, then process 60 determines if the threshold E_b/N_o is at maximum, decision step 68. If the threshold is at maximum, process 60 ends, step 66. If the threshold is not at maximum, the threshold value is incremented, but not to exceed maximum threshold, step 69. Process 60 then loops back to step 62.

Timing of the E_b/N_o changes may also be implemented to prevent the E_b/N_o level from changing prematurely do to some temporary anomaly. In the above embodiment, if the pilot is less than or equal to the threshold level, the threshold will be set equal to the pilot without delay. This is necessary to keep the system for escalating power out of control. If the pilot is greater than the threshold level for 200 msec, then the threshold is increased by 0.2 dB every 200 msec with an upper limit of the maximum threshold level.

Referring again to the graph of FIG. 4, the slope of the E_b/N_o curves approach infinity as the number of system users approaches a maximum. This sharp slope of the curve near ideal capacity causes power control instabilities. The reverse pilot provides an absolute limit to the users power to prevent power control run away. The reverse pilot allows accurate E_b/N_o control

for heavily loaded cells. The reverse pilot is a constant power spread spectrum transmitter that the cell site can receive and compare power control versus the other users. Since the pilot is at constant power, when the site is at low capacity, the base station will see the reverse pilot E_b/N_o higher than the threshold. At high capacity, the base station will see the reverse pilot E_b/N_o lower than the threshold and will readjust the power of the subscribers to match the E_b/N_o of the reverse pilot.

The location of the reverse pilot may be placed at the cell boundary with its constant power set for a 300 milliwatt -4 dB margin, to represent the range of a portable. However, a preferable location for the reverse pilot is at the base station receiver. This will prevent it from interfering with adjacent cells. While the power of the pilot signal is fixed, it may be adjusted to increase or decrease the cell range. This adjustment may be based upon: time of day factors; change of demographics within the cell; or various other factors.

As will be understood, the pilot signal will utilize some of the capacity of the system. The pilot power may represent a full user or as little as 1/8 user. At 1/8 user, the pilot would occupy very little of the capacity of the system and in many instances have no practical effect. For example, in FIG. 4, the ideal number of full rate users for E_b/N_os of 6, 7, and 8 dB is 33.2, 26.5, and 21.3 respectively. A deduction of .125 users (1/8) would reduce the capacity by much less than 1%.

Referring to FIGS. 7A-7C, abstract representations of power usage by user are presented incorporating the pilot signal. Starting with FIGS. 7A and 7B, it is

shown that at less than capacity, the pilot and KTB take the same amount of power. Specifically, with regard to FIG. 7A, placing the pilot and KTB signals at -113 dBm (1.2288 MHz) will require that the user signal be at -124 dBm (9.6 KHz) to maintain an E_b/N_o of 7 dB. This is illustrated in FIG. 8 where the total noise is at -110 dBm (1.2288 MHz) which when converted is -131 dBm (-110 - 21). In order to provide an E_b/N_o of 7 dB a -124 dBm (at 1.2288 MHz) of signal is required. The same calculations for 20 users, FIG. 7B, finds that each user must transmit at a power level of -118 dBm. These figures are 3 dBm higher than their counter parts without the pilot signal.

In FIG. 7C, the system has reached 24.5 users, the point where KTB and the pilot each have the same power as one user. This results in 25.5 user equivalents (23.5 users plus KTB and the pilot) contributing noise to the call of a single user. Again, the area of KTB and the pilot have remained the same throughout the addition of users, while the power of user 1 has increased to compensate for the additional user noise. In this example, the use of a full rate pilot has reduced the capacity of the cell by one as compared to FIG. 1C. With the use of a 1/8 rate pilot, most of the lost capacity could be recovered.

The results of using a pilot are also demonstrated in FIG. 4. Assuming a maximum threshold E_b/N_o of 7 dB and a minimum threshold E_b/N_o of 6 dB, the user signal power as a function of noise will grow along the 7 dB E_b/N_o line until the reverse pilot signal, set here at 21 dB, is reached. At this point, there are approximately 25 users on the system. In addition, the E_b/N_o of the users is equal to the E_b/N_o of the pilot. When the next user is added, the user signal power would

be increased by the system to maintain E_b/N_o at 7 dB. This would result in the E_b/N_o of the pilot being less than the user (less than 7 dB). The present invention would decrease the threshold level to equal the new E_b/N_o of the pilot signal. This places a limit on the users power use and guards against a run away condition.

As the system continues to add users, the E_b/N_o of the system will continue to be reduced until a minimum threshold level is reached. For example, if the minimum threshold were set to 6 dBm, only 32 users would be permitted on the system. Any additional users would either be prevented from entering the system, or be handed off to another cell. Alternatively, the system could be constructed to look to hand-off and existing user to make room for a new user.

When calls are terminated and the number of users is reduced, the power of the users would be handled in the reverse of the procedure just discussed.

Therefore, a means has been shown which helps eliminate power control run away in a communication system.

Thus, it will be apparent to one skilled in the art that there has been provided in accordance with the invention, a method for compensating for capacity overload in a spread spectrum communication system that fully satisfies the objects, aims, and advantages set forth above.

While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alterations, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alterations, modifications, and variations in the appended claims.

Claims

1. A method of compensating for capacity overload in a spread spectrum communication system comprising the steps of:

determining a receiver site power level at a first base site of said spread spectrum communication system;

comparing said receiver site power level to a threshold power level;

adjusting a signal-to-noise ratio for said spread spectrum communication system at said first base site if said receiver site power level is greater than said threshold power level;

transmitting a power control signal from said first base site to a subscriber of said spread spectrum communication system; and

adjusting a transmit power of said subscriber in response to said power control signal.

2. The method of claim 1 whereby adjusting said transmit power of said subscriber reduces said receiver site power level to a reduced receiver site power level.

3. The method of claim 2 wherein said spread spectrum communication system has a maximum threshold power level and a minimum threshold power level.

4. The method of claim 3 wherein said receiver site power level is compared to said maximum threshold power level.

5. A method of compensating for capacity overload in a spread spectrum communication system comprising the steps of:

determining a signal-to-noise ratio of a pilot signal of a pilot of said spread spectrum communication system;

comparing said signal-to-noise ratio to a threshold signal-to-noise ratio;

adjusting said threshold signal-to-noise ratio for said spread spectrum communication system at a first base site if said signal-to-noise ratio is less than said threshold signal-to-noise ratio;

transmitting a power control signal from said first base site to a subscriber of said spread spectrum communication system; and

adjusting a transmit power of said subscriber in response to said power control signal.

6. The method of claim 5 wherein said spread spectrum communication system has a maximum threshold signal-to-noise ratio and a minimum threshold signal-to-noise ratio.

7. The method of claim 6 wherein said pilot signal-to-noise ratio is compared to said maximum threshold signal-to-noise ratio.

8. The method of claim 7 wherein said pilot signal-to-noise ratio is said minimum threshold signal-to-noise ratio.

9. A spread spectrum communication system comprising:

determining means for determining a receiver site power level at a base site of said spread spectrum communication system;

comparing means coupled to said determining means for comparing said receiver site power level to a threshold power level;

adjusting means coupled to said comparing means for adjusting a signal-to-noise ratio for said spread spectrum communication system at said base site if said receiver site power level is greater than said threshold power level;

transmitting means coupled to said adjusting means for transmitting a power control signal from said base site to a subscriber of said spread spectrum communication system; and

adjusting means at said subscriber for adjusting a transmit power of said subscriber in response to said power control signal.

10. A spread spectrum communication system comprising:

determining means for determining a signal-to-noise ratio of a pilot signal of a pilot of said spread spectrum communication system;

comparing means coupled to said determining means to compare said signal-to-noise ratio to a threshold signal-to-noise ratio;

adjusting means coupled to said comparing means for adjusting said threshold signal-to-noise ratio for said spread spectrum communication system at said base site if said signal-to-noise ratio is less than said threshold signal-to-noise ratio;

transmitting means coupled to said adjusting means for transmitting a power control signal from said base site to a subscriber of said spread spectrum communication system; and

adjusting means at said subscriber for adjusting a transmit power of said subscriber in response to said power control signal.

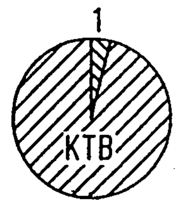

FIG.1A

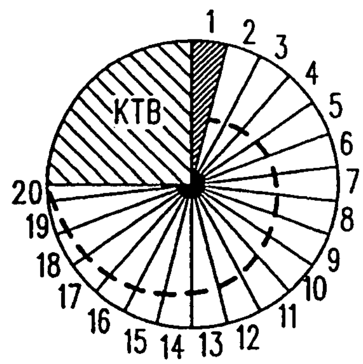

FIG.1B

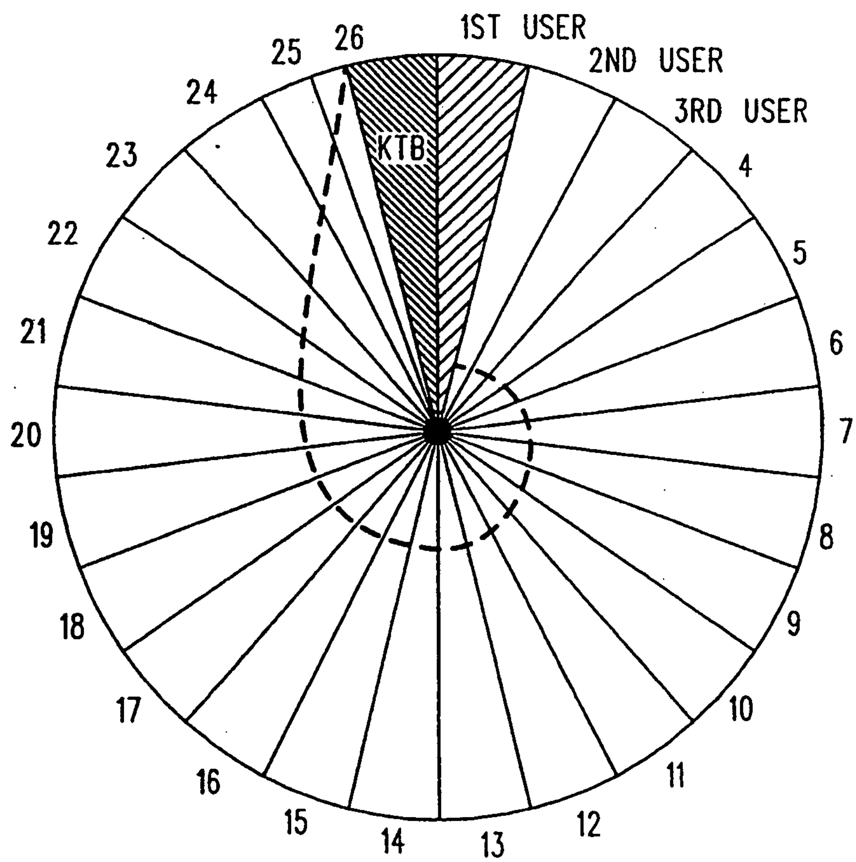

FIG.1C

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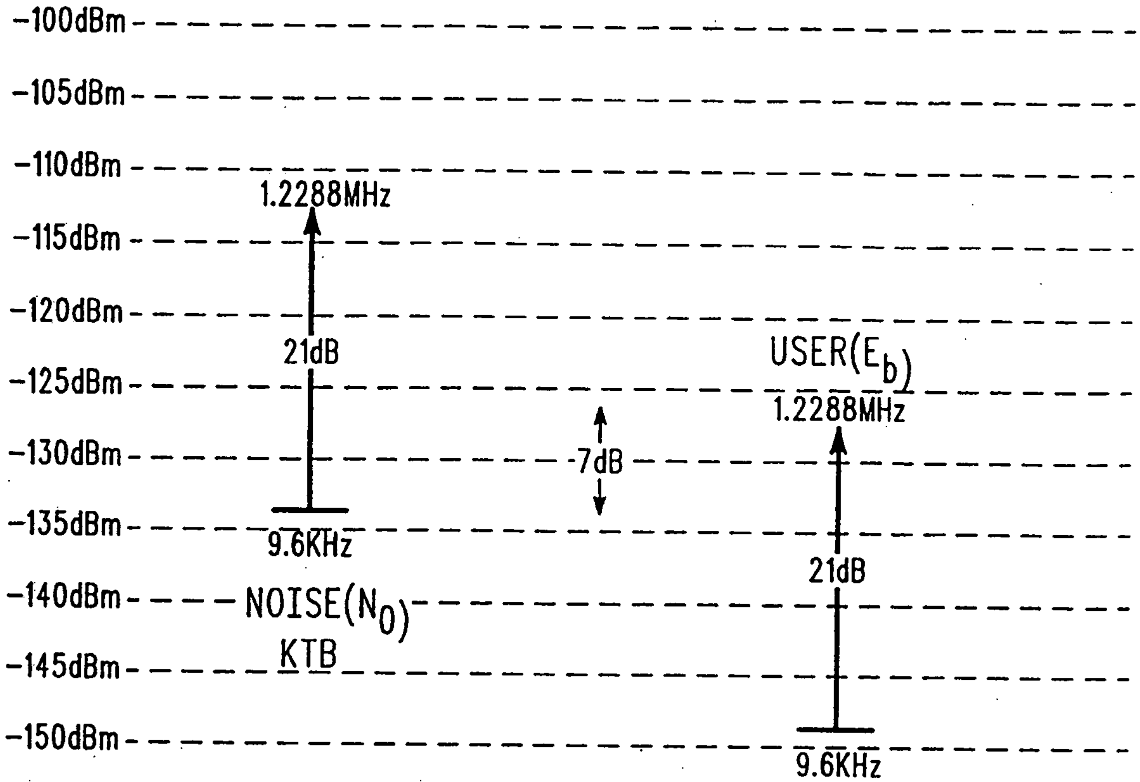
-100dBm
-105dBm
-110dBm
1.2288MHz
-115dBm
-120dBm
21dB
USER(E_b)
-125dBm
1.2288MHz
-130dBm
-7dB
-135dBm
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21dB
-140dBm
NOISE(N_0)
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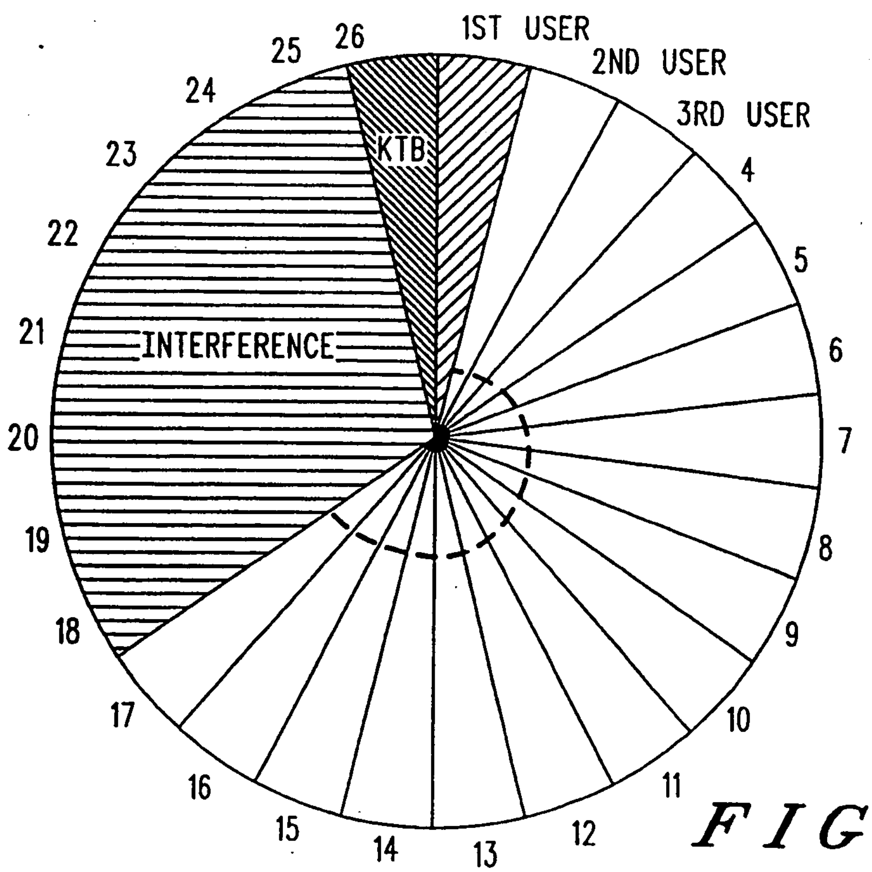
FIG.2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26
KTB
INTERFERENCE

FIG.5

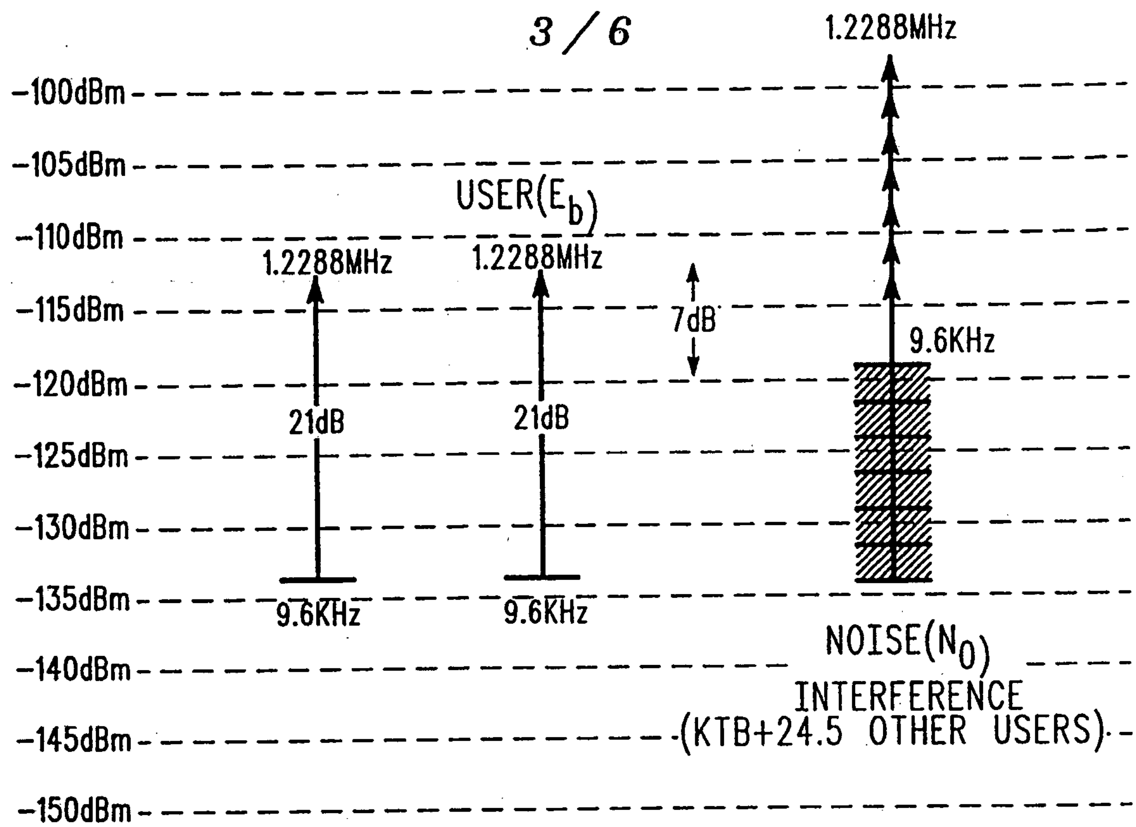


FIG. 3

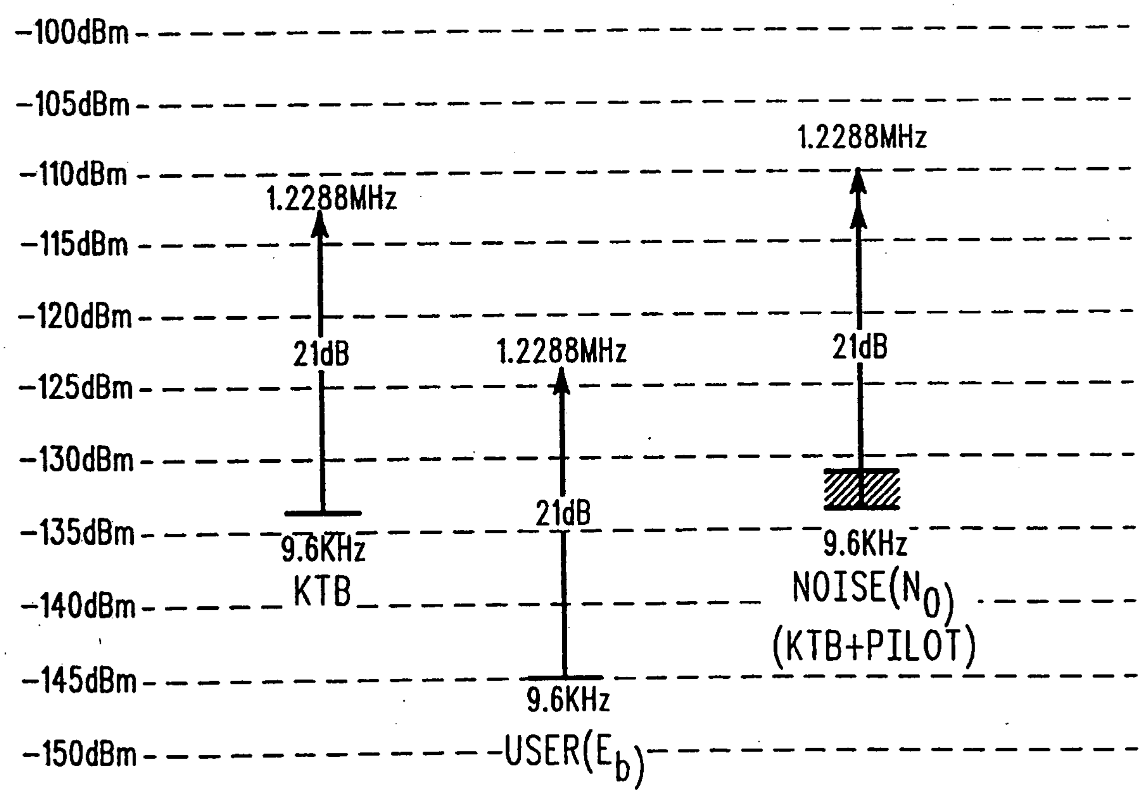
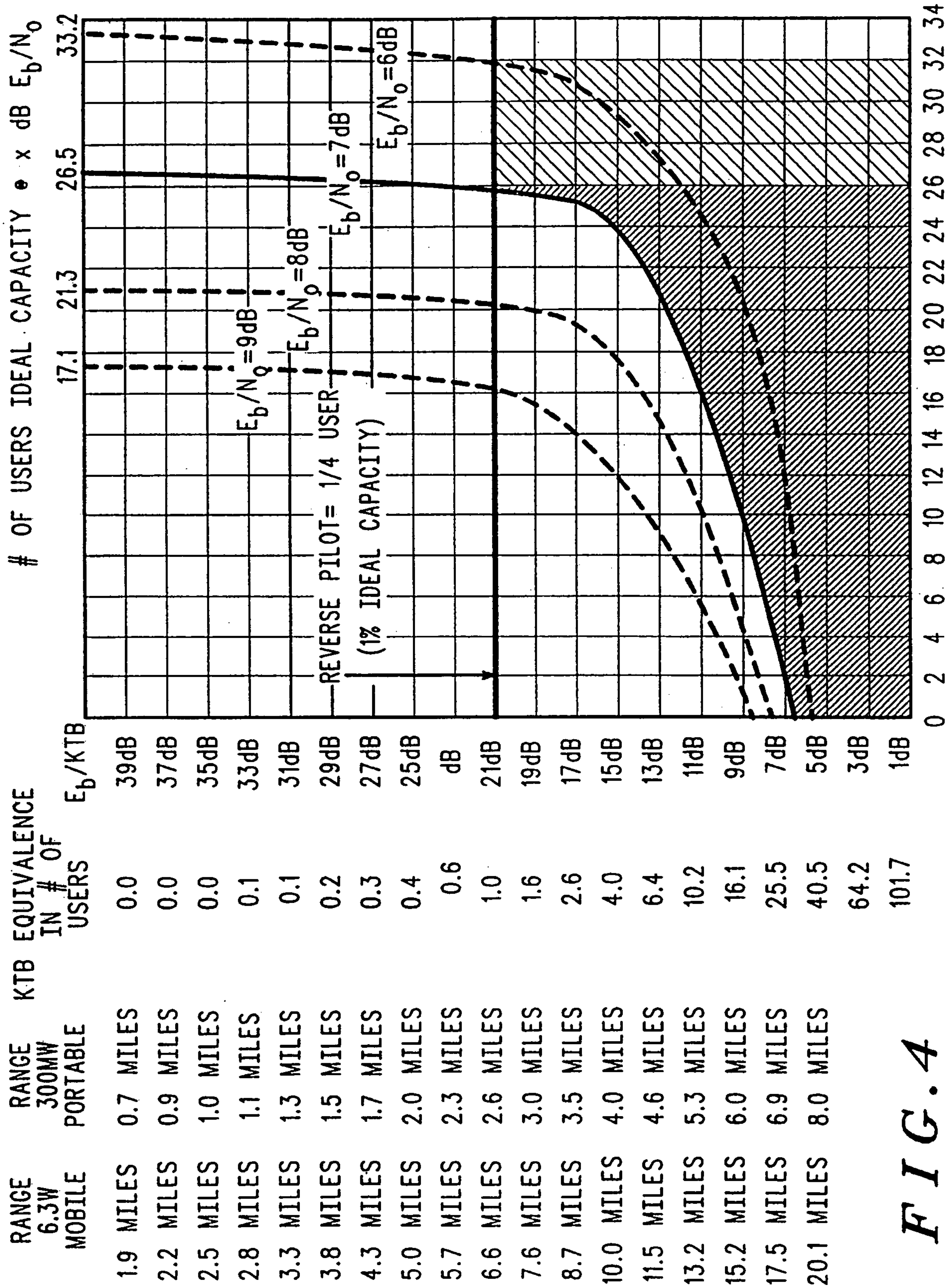


FIG. 8

00001



OF USERS IDEAL CAPACITY • x dB E_b/N_o
33.2
26.5
21.3
17.1
E_b/N_o=6dB
E_b/N_o=7dB
E_b/N_o=8dB
E_b/N_o=9dB
REVERSE PILOT= 1/4 USER
(1% IDEAL CAPACITY)
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
RANGE 6.3W MOBILE
RANGE 300MW PORTABLE
KTB EQUIVALENCE IN # OF USERS
E_b/KTB
1.9 MILES 0.7 MILES 0.0 39dB
2.2 MILES 0.9 MILES 0.0 37dB
2.5 MILES 1.0 MILES 0.0 35dB
2.8 MILES 1.1 MILES 0.1 33dB
3.3 MILES 1.3 MILES 0.1 31dB
3.8 MILES 1.5 MILES 0.2 29dB
4.3 MILES 1.7 MILES 0.3 27dB
5.0 MILES 2.0 MILES 0.4 25dB
5.7 MILES 2.3 MILES 0.6 dB
6.6 MILES 2.6 MILES 1.0 21dB
7.6 MILES 3.0 MILES 1.6 19dB
8.7 MILES 3.5 MILES 2.6 17dB
10.0 MILES 4.0 MILES 4.0 15dB
11.5 MILES 4.6 MILES 6.4 13dB
13.2 MILES 5.3 MILES 10.2 11dB
15.2 MILES 6.0 MILES 16.1 9dB
17.5 MILES 6.9 MILES 25.5 7dB
20.1 MILES 8.0 MILES 40.5 5dB
64.2 3dB
101.7 1dB

FIG. 4

00001

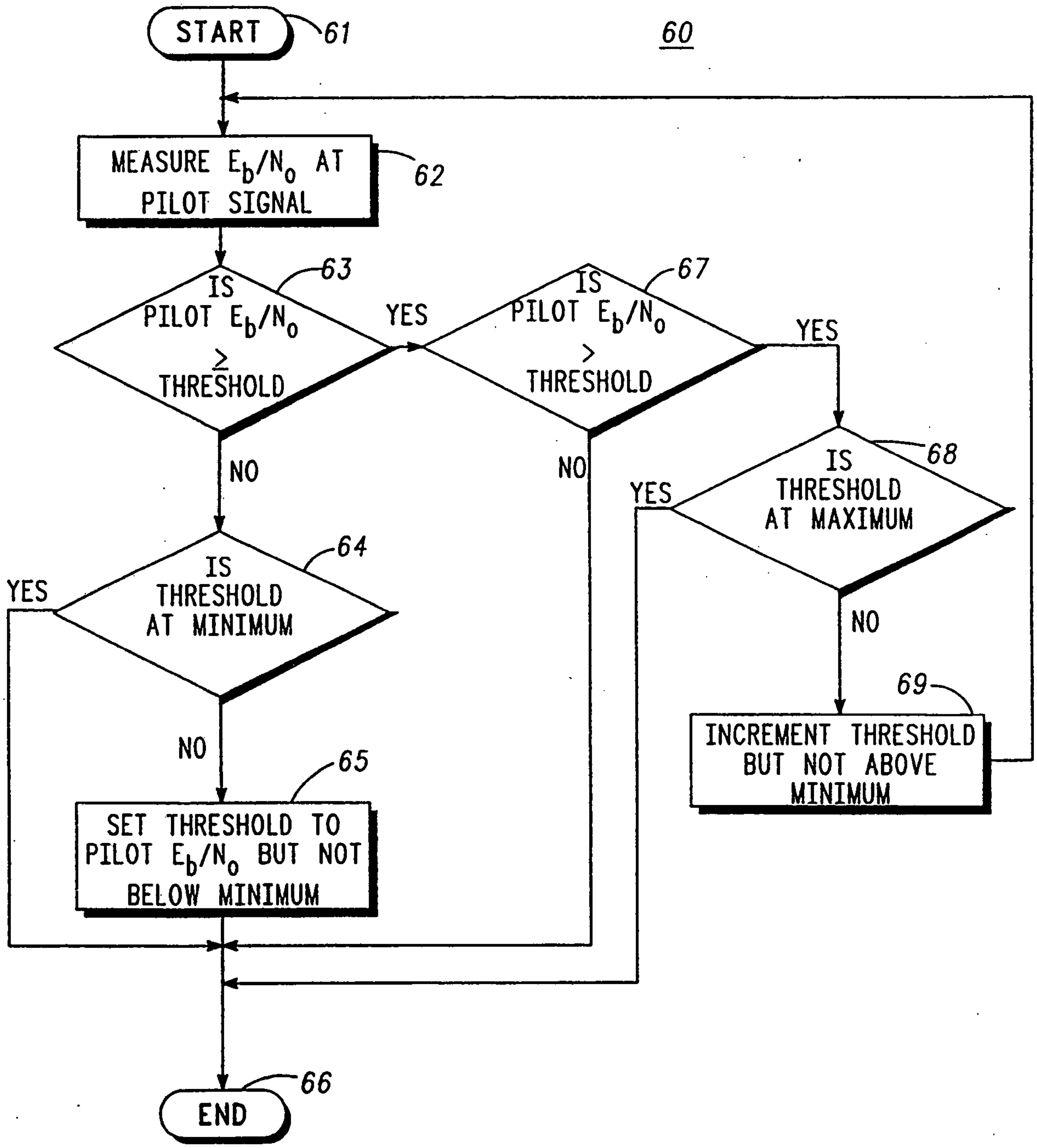

START
61
60
MEASURE E_b/N_o AT PILOT SIGNAL
62
IS PILOT E_b/N_o ≥ THRESHOLD
63
YES
IS PILOT E_b/N_o > THRESHOLD
67
YES
NO
NO
IS THRESHOLD AT MAXIMUM
68
YES
NO
IS THRESHOLD AT MINIMUM
64
YES
NO
INCREMENT THRESHOLD BUT NOT ABOVE MINIMUM
69
SET THRESHOLD TO PILOT E_b/N_o BUT NOT BELOW MINIMUM
65
END
66

FIG. 6

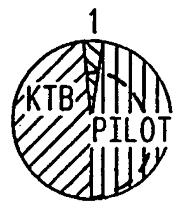


FIG.7A

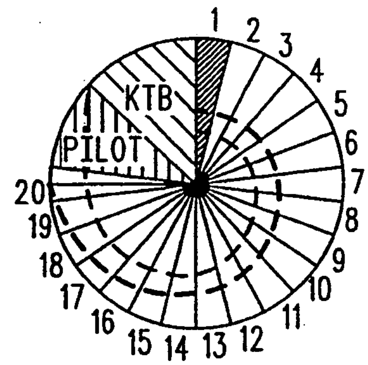


FIG.7B

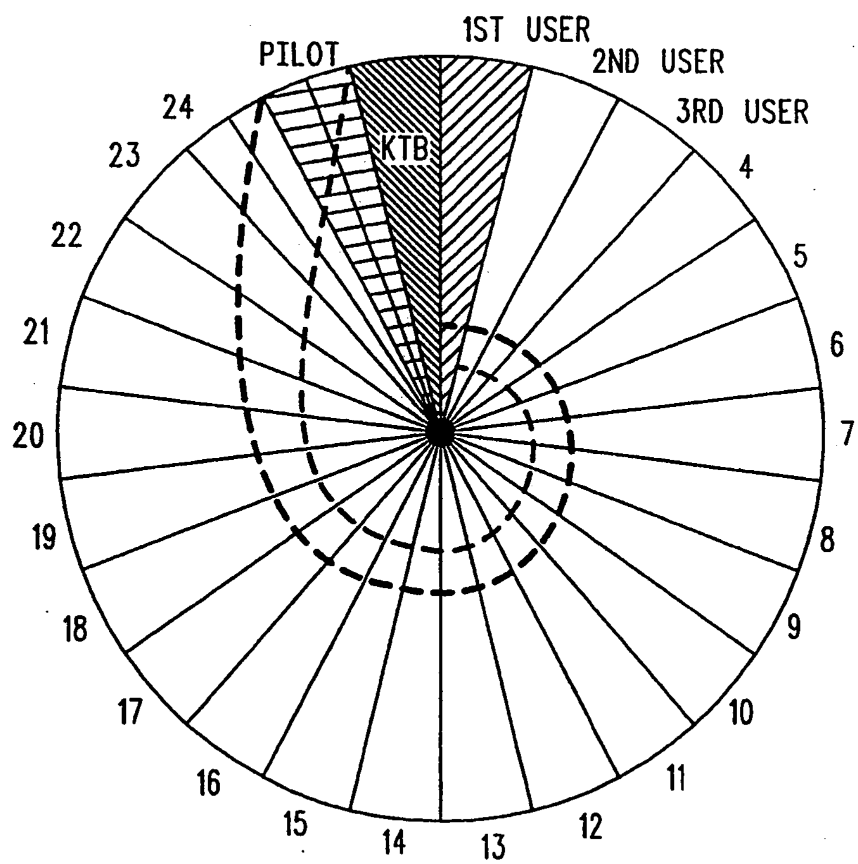


FIG.7C

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INTERNATIONAL SEARCH REPORT

PCT/US92/08435

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) : H04L 27/30 H04K 1/04

US CL :375/1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 375/1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,222,115 (COOPER ET AL), 09 SPETEMBER 1980, See col. 5, lines 5-20.	1-10
A	US,A, 4,901,307, (GILHOUSEN ET AL), 13 FEBRUARY 1990,(See cols 13-16).	1-10
Y	US,A, 5,056,109 (GILHOUSEN ET AL), 08 OCTOBER 1991, See entire document.	1-10
A,P	US,A, 5,073,900 (MALLINCKRODT), 17 DECEMBER 1991, See cols 8-11.	1-10
Y,P	US,A, 5,093,840 (SCHILLING), 03 MARCH 1992, See entire document.	1-10

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
02 DECEMBER 1992	21 DEC 1992

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/08435

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	US,A, 5,101,501 (GILHOUSEN ET AL), 31 MARCH 1992, See entire document.	1-10
A,P	US,A, 5,109,390 (GILHOUSEN ET AL), 28 APRIL 1992, See entire document.	1-10
A,E	US,A, 5,161,168 (SCHILLING), 03 NOVEMBER 1992, See entire document.	1-10
Y,E	US,A, 5,164,958 (OMURA), 17 NOVEMBER 1992, See cols 14-17.	1-10

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